REPORT OF THE
DEPARTMENT OF RAIL AND PUBLIC TRANSPORTATION

TransDominion Express Status Update Study

TO THE GOVERNOR AND
THE GENERAL ASSEMBLY OF VIRGINIA

HOUSE DOCUMENT NO. 2

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COMMONWEALTH of VIRGINIA

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January 3, 2007

The Honorable John H. Chichester
Chairman, Senate Finance Committee
General Assembly Building, Room 626
Richmond, Virginia 23219

The Honorable Vincent F. Callahan, Jr.
Chairman, House Appropriations Committee
General Assembly Building, Room 947
Richmond, Virginia 23219

Dear Senator Chichester and Delegate Callahan:

The 2006 General Assembly directed the Department of Rail and Public Transportation (DRPT) to update the status of the proposed passenger rail service between Bristol, Richmond, and Washington, D.C. known as the TransDominion Express (TDX). The General Assembly specifically requested that the following be updated: the project's expected capital cost, operating cost, revenue projections, feasibility of reducing traffic congestion, and status. At the request of DRPT, the Virginia Transportation Research Council has prepared the attached study to address these questions.

This study suggests that to initiate full service, a capital investment of $206 million (in 2010 dollars) would be required to accommodate passenger service running on Norfolk Southern Railway Company right of way. These funds will provide for the purchase of locomotives, passenger cars, and rail infrastructure improvements, including upgrades of passing tracks and the construction of stations necessary to operate this service. Annual operating costs (also in 2010 dollars) are expected to be about $19 million, with between $0.4 million and $1.8 million collected in revenues. Operation of the TDX will require a subsidy of $3.91 per passenger mile compared to a subsidy of between $0.20 and $0.25 per passenger mile for the other intercity rail services studied in this report.

The ridership and subsidy performance estimates contained in this study do not by themselves justify a decision to implement TDX service on the basis of reduced congestion. Any decision to advance TDX and make investments of public money will be based on other factors not evaluated in this report, such as the potential for economic development, tourism, and improved mobility options. Additionally, any investment should only be made after further analysis of

public and private benefits garnered by both the Commonwealth and Norfolk Southern Railway Company along with the execution of an agreement that provides for appropriate sharing of costs and benefits.

This most recent report represents the sixth time that TDX service has been studied. In 2000, funding of approximately $9.3 million was appropriated as part of the Virginia Transportation Act for capital needs. No on-going source of capital and operating funds has been identified to further advance TDX into operations. Nor has a governing entity been created and an agreement with Norfolk Southern executed that would allow operations. A comprehensive strategy must be developed to advance the decision-making process regarding the implementation of the TDX. The comprehensive strategy must update cost information and address the following questions:

1. *Does the implementation of this service provide a public benefit?* The purchase of railcars and improvements in rail infrastructure to support passenger rail operations require that the Commonwealth identify a clear public benefit for passenger rail independently of joint passenger and freight rail operations. Given the findings of this report that the TDX does not reduce traffic congestion, further analysis based on economic development, tourism, and improved mobility options should be undertaken.

2. *What will be the governance structure for TDX?* Several different governance entities have previously been proposed. A bill to create an Authority for TDX was considered but not adopted during the 2006 General Assembly session. The Virginia Railway Express (VRE) model of governance by the jurisdictions receiving service has also be suggested. Additional study needs to be conducted to determine the optimal governance structure for TDX.

3. *Which entity will operate the TDX?* The entity could be the rail owner (e.g., Norfolk Southern), the current long distance rail provider (e.g., Amtrak), or a third party.

4. *How will the TDX fund its operating and capital needs?* Will the localities reach a funding agreement similar to the agreement that supports VRE operations and capital needs? Is the Commonwealth willing to provide sufficient funding to support the implementation and on-going costs of this service?

5. *Can Norfolk Southern, the TDX Governing Entity and the Commonwealth reach an operating and cost sharing agreement?* Costs should be appropriately shared for improvements that benefit both passenger and freight rail. Additionally, it must be determined whether or not passenger service will remain viable following the implementation of the Heartland Corridor and the I-81 Corridor Rail Initiatives.

In conclusion, DRPT and Virginia Transportation Research Council staff are available to answer questions or provide presentations regarding this report.

Sincerely,

Matthew O. Tucker
Director

cc: Honorable Pierce R. Homer

Attachment

PREFACE

Item 438.B of HB 5002 in the Chapter 3 Acts of Assembly (the Budget Bill for 2006–2008 biennium) directed the Virginia Department of Rail and Public Transportation (DRPT) to provide updated information regarding the status of proposed passenger rail service between Bristol, Richmond, and Washington, DC. This report responds to that request.

The study was directed by Wayne Ferguson of the Virginia Transportation Research Council (VTRC). The report was authored by John Miller, Frank Thorn, and Jason Beaton and was edited by Linda Evans, all of VTRC. Randy Combs of VTRC assisted with graphics.

The authors gratefully acknowledge several individuals who provided invaluable assistance. C. Rockey and F. Hardesty of the American Association of Railroads provided materials that were helpful for updating the capital cost estimates. D. Galloway and J. Mann of the National Railroad Passenger Corporation (Amtrak) answered questions regarding Amtrak operations in Virginia. P. Douglass, P. Simmons, E. Skoropowski, and E. Uzanski provided information regarding the Downeaster line (Maine and Massachusetts), the Piedmont line (North Carolina), the Capitol Corridors line (California), and the Cascades line (Oregon and Washington). N. Friend and A. Perez provided information on the use of Talgo technology. These contributions do not necessarily indicate agreement with this report, however, and the authors alone are responsible for errors or omissions.

The study updates work conducted previously, as the concept of TDX is now under review for the sixth time since 1996. The greatest emphasis in this study was placed on estimating ridership as a function of service levels, as the forecasts for ridership have varied among previous studies.

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EXECUTIVE SUMMARY

Background

Item 438.B of HB 5002 in Chapter 3 Acts of Assembly (the Budget Bill for the 2006–2008 biennium) directed the Virginia Department of Rail and Public Transportation (DRPT) to update the status of proposed passenger rail service, called the TransDominion Express (TDX), between Bristol, Richmond, and Washington, DC. Specifically:

> The Department shall report to the Chairmen of the Senate Finance and House Appropriations Committees on the transportation project authorized under the Virginia Transportation Act of 2000 to provide passenger rail service between the Cities of Bristol and Richmond, and Washington, DC. In addition to the project's status, the Department shall include revised information on capital and operating costs, potential revenue of such passenger service, and the project's potential benefits to alleviate congestion on the state's Interstate and highway system of roads (Virginia General Assembly, 2006).

No funds have been allocated for operating TDX or making related capital improvements, except for an allocation of slightly more than $9 million for capital projects as part of the Virginia Transportation Act of 2000.

Five studies of TDX have been conducted during the past 10 years:

1. in 1996, by DRPT at the request of the General Assembly (Virginia Department of Rail and Public Transportation, 1996)

2. in 1998, by Frederic R. Harris, Inc., at the request of DRPT in response to funding made available for such a study by the General Assembly in 1996 (Frederic R. Harris, Inc., 1998)

3. in 2000, by the National Passenger Railroad Corporation (Amtrak) at the request of DRPT (National Railroad Passenger Corporation, 2000)

4. in 2002, by The Woodside Consulting Group, Inc. (Woodside Consulting), at the request of Norfolk Southern and DRPT (Woodside Consulting, 2002)

5. in 2005, by DRPT (Virginia Department of Rail and Public Transportation, 2005).

The estimated annual operating subsidies varied in these studies, ranging from $9 million to $23 million depending on the type of service presumed and the ridership level. Capital costs were estimated in the greatest detail in the 2002 study and those capital costs were generally used in the 2005 DRPT study.

The greatest variation in the studies, however, concerned their ridership estimates: the lowest estimated annual ridership was in the 2000 Amtrak study (slightly more than 26,000) and the highest was in the 1996 DRPT study (slightly more than 0.5 million). Differences in ridership projections are attributed to (1) the service levels that would be provided (earlier studies suggested that modern tilt equipment was feasible, which would offer faster service,

whereas the studies since 2000 suggested such equipment may not be used and thus slower service times would result); (2) the sensitivity of ridership to varying service levels (e.g., a travel time of x between two stations will yield the portion of total travel choosing to use rail); and (3) assumptions regarding the impact of freight on passenger travel schedules (since any TDX passenger service would be subject to freight movements by Norfolk Southern, the owner of the rail on which TDX would operate).

As part of this update, this study focused on four critical areas: (1) updating capital costs, (2) updating ridership estimates based on the sensitivity of demand to service levels, (3) the expected revenue and necessary subsidies based on these ridership projections, and (4) indicating the congestion benefits of TDX.

This study also includes an action plan for moving TDX forward should the Commonwealth or others desire to do so. Inclusion of the action plan does not guarantee that any public entity, such as DRPT, or private entity, such as Norfolk Southern, necessarily believes TDX is a wise investment of resources at this time. The action plan is included, however, because item 438.B of HB 5002 specifies that this report should provide an update on the status of TDX. The action plan identifies institutional issues that affect how TDX could be implemented. These include identifying a stable revenue stream for future years of service, choosing a governance structure, identifying how improvements can be phased over time, and measuring the performance of the new system.

Findings

- *Capital costs for improvements for infrastructure to support full service between Bristol, Richmond, and Washington, DC, are estimated at approximately $206 million (in 2010 dollars). Rolling stock cost estimates vary depending on the type of passenger cars acquired.*

- *Annual operating costs for full service are estimated at $19 million (in 2010 dollars), presuming two round trip visits to all stations.*

- *Ridership is estimated at 14,000 to 58,000 persons annually, assuming service levels proposed by Woodside Consulting in 2002, which were more conservative (e.g., lower) than those assumed in the preceding study in 1998*. The 2002 service levels entail comparable travel times between the auto and the train for a few routes (such as Charlottesville to Alexandria) but often longer times for train as compared to the auto for most routes; the intercity train travel times used in this study are given in Table B1 in Appendix B. A range is given because previous reports used different assumptions regarding the relationship between rail demand and rail service time, and the exact relationship simply is not known. Previous reports suggest four travel demand functions that may be generated, and the range given captures the highest and lowest travel estimates. Data from other locations (e.g., the Downeaster line from Maine to Boston, the Cascades Corridor in Washington State, and the Capitol Corridor in California) suggest that service times alone are rarely changed; rather, improvements such as providing electrical outlets for business travelers, using wider seats, offering better beverage service, and offering other amenities are often made in tandem with

such changes. Thus, determining sensitivity to changes in service levels alone is difficult, necessitating presentation of forecasts as a range rather than a point estimate.

- *Ridership varies by station location*. For example, it is estimated that 70% of TDX ridership would occur at stations between Lynchburg and Alexandria inclusive (Tables 8 and 10). While each additional station may add riders, some stations add more riders than others.

- *Based on the estimated ridership levels, revenue is projected to be between $0.4 million and $1.8 million annually in 2010 dollars. Based on operating costs of $19 million annually (in 2010 dollars), a subsidy of between $17.2 and $18.6 million will be required.* This means that about 6% of the cost to operate TDX will be borne by users of the service. Elsewhere, users pay between 43% and 51% of the cost for service, as shown in Table ES1.

- *TDX offers little benefit in terms of reducing travel congestion.* Daily traffic volumes on some roads, such as Route 29 in Prince William County, are higher than the estimated annual passenger travel on TDX. However, TDX may offer benefits in terms of providing an alternative mode of transportation to a variety of travel markets, including tourists, college students, and households without vehicles, and within specific corridors. For example, proposed service levels suggest that TDX would offer faster service than the automobile for the segment between Charlottesville and Alexandria.

- *The status of TDX has not changed since the publication of the 2005 report (DRPT, 2005).*

- *Two external circumstances affecting the feasibility of TDX have changed*. First, Norfolk Southern has received Rail Enhancement Funds of $22.35 million over a 3-year period to make improvements to Norfolk Southern track between Walton, Virginia, and Glen Lyn, Virginia (which will allow double-stacked freight by improving clearances in four tunnels) and to construct an intermodal terminal in Roanoke (DRPT, 2006; Martinez, 2005). This set of improvements is a part of a larger plan by Norfolk Southern to improve freight capacity between Hampton Roads and Columbus, Ohio, and is generally known as the *Heartland Corridor Double-Stack Initiative*. Second, the Commonwealth is studying ways to reduce truck traffic in the I-81 corridor, including up to a "60 percent diversion of trucks off of I-81" on to Norfolk Southern lines (Page, 2006). This effort is known as the *I-81 Rail Corridor Study*. Both may increase freight traffic on existing Norfolk Southern lines that would be used by TDX, thereby possibly making passenger service operations more difficult. Whether either item will lead to any capacity improvements that benefit passenger operations is not known at this time, and the impact of these efforts is not reflected in this study.

Discussion

The forecasts for this study are detailed in Appendices B and C and in the accompanying spreadsheets, accessible at http://www.vtrc.net/tdxforecasts. As stated previously, ridership is forecast at 14,000 to 58,000 persons annually, with that range based on the conservative service levels from the 2002 study, although there are five considerations that affect the reliability of these forecasts. First, the literature (Vaca, 1993) and remarks from an expert (Eugene

Skoropowski, Personal Communication, October 20, 2006) caution that ridership forecasts often have substantial error, especially when new service is being proposed. Second, the impact on ridership of service improvements has been shown to vary by location where such improvements were made (Evans, 2004). Third, the literature further suggests there may be challenges to the development of reliable forecasts for other rail or transit projects (Government Accountability Office (GAO), 2006). Fourth, evidence from other passenger service operations shows that although service time, frequency, and reliability are critical determinants of ridership, they are not the only such determinants: amenities such as food and beverage service, seating comfort, and customer service also play a role (Northern New England Passenger Rail Authority, 2005; Perl, 2000; Washington State Department of Transportation, 2004). Fifth, although this study did not assume the use of modern tilt technology, the feasibility of such technology cannot be ruled out until a five-way discussion among the manufacturer, Virginia, Norfolk Southern, the rail operator, and the Federal Railroad Administration can eliminate such an option. Such technology could affect these forecasts if it were ever shown to be feasible.

The forecasts also suggest that full service for TDX might require a capital investment of $206 million in 2010 dollars coupled with an annual operating subsidy of approximately $18 million. Although it is not uncommon for intercity passenger rail services to require a subsidy, the amount of subsidy required for TDX is relatively large when compared to those of other services, as indicated in Table ES1. The total operating subsidy estimate for TDX is exceeded only by that for the Capitol Corridor system ($20.24 million annually in 2006 dollars as shown in Table ES1 or $24.14 million annually in 2010 dollars). Although the operating costs for TDX are the same order of magnitude as those of these other systems, TDX would require a substantially larger subsidy per passenger mile than these other systems: a subsidy of $3.91 per passenger mile for TDX compared to an average of $0.27 per passenger mile for the other systems included in this report, all in 2010 dollars. (The TDX subsidy of $3.91 per passenger mile is based on the estimate of 36,000 riders; with only 14,000 riders and the same total subsidy, the subsidy would be $10.04 per passenger mile; and with only 58,000 riders, the subsidy would be $2.42 per passenger mile, all in 2010 dollars).

All four systems shown in Table ES1 receive an operating subsidy. One way to determine whether this subsidy is justified is to compare the subsidy to the public benefits of the system. The literature suggests that motor vehicle use exacts an unpaid social cost in the form of crashes, energy, noise pollution, air pollution, parking, user costs, and infrastructure investments, with estimates ranging from 3.4 to 55.3 cents per passenger mile (Meyer and Miller, 2001). If it is assumed that every rail service passenger mile eliminates an automobile passenger mile, then a rail service *public benefit* might be between 3.4 and 55.3 cents per passenger mile. For three of the systems shown in Table ES1, the *public subsidy* is between $0.24 and $0.29 per passenger mile (in 2010 dollars). Thus, although there might be debate as to whether the public benefit should be low (3.4 cents per passenger mile), high (55.3 cents per passenger mile) or in the middle of these two values (29.3 cents per passenger mile), it can be said that for three of the systems, the public benefit and public subsidy are at least of a similar order of magnitude. However, the public subsidy of TDX is much larger—about $3.91 per passenger mile. Thus, regardless of which public benefit number is chosen (3.4, 55.3, or a number in between), the subsidy for TDX exceeds the public benefit of TDX. However, a different finding could result if any of the following three assumptions changes: (1) the proposed figures for TDX in Table ES1

Table ES1. Benchmarks of Other Services

Benchmark	Downeaster	Capitol Corridor	Amtrak Cascades	TDX (Proposed)[a]
2005 Total Ridership	293,653[b]	1,260,249[c]	420,920[d]	36,000[e]
2005 Revenue	$3.812 million[b]	$15.27 million[c]	$10.095 million[d]	$1.143 million[e]
2005 Revenue per Passenger	$12.98[f]	$12.12[f]	$23.98[d]	$31.75[f]
2005 Fare per Mile	$0.17[g]	$0.18[f]	$0.21[d]	$0.25 (assumed)
2005 Costs Not Covered by Fares (Subsidy)	$5.231 million[h]	$20.24 million[i]	$12.18 million[d]	$17.857 million[f]
2005 Total Passenger Miles	22.426 million[f]	85.9 million[j]	58.7 million[d]	4.572 million[f]
2005 Subsidy per Passenger Mile	$0.23[f,k]	$0.24 [f,k]	$0.20[d,k]	$3.91[f]

[a]All TDX revenues and costs are in 2010 dollars to enable consistency with the figures presented elsewhere in this report. It is assumed that the Downeaster, Capitol Corridor, and Amtrak Cascades figures are in 2006 dollars.
[b]Douglass, P. *Performance Report: December 2005.* Northern New England Passenger Rail Authority. Portland, ME, 2006. www.thedowneaster.com. Accessed October 24, 2006.
[c]Capitol Corridor Joint Powers Authority. *The Capitol Corridor 2005 Performance Report.* Oakland, CA, 2006. http://www.capitolcorridor.org/included/docs/ccjpa/perfreport05.pdf. Accessed October 19, 2006.
[d]Carolyn Simmonds, Personal Communication, December 1, 2006. This information reflects only the Washington state sponsored portion of the service.
[e]Value is the average of the low and high values derived in this report.
[f]Derived from other values in the same column. For example, the 2005 total passenger miles for the Downeaster (22.426 million) is based on $3,812,420 in revenues divided by $0.17 in fares per mile.
[g]Patricia Douglass, Personal Communication, October 25, 2006.
[h]Patricia Douglass, Personal Communication, December 6, 2006, where the following document was sent: "Expected Actuals 2006: Board Approved Budget, June 26, 2006." Because only the 2006 figure (not 2005) was available, the following calculations were performed to derive the figure of $5.231 million shown: the 2006 total expenses ($11,262,864) and the 2006 total revenue ($4,748,105) yield a revenue/expense ratio of 42.2%. Application of this ratio to the 2005 revenue suggests 2005 total expenses of $9.043 million, yielding an estimated 2005 subsidy of $5.23 million, as shown in the table.
[i]The 2005 report by the Capitol Corridor Joint Powers Authority cites a 43% revenue to cost ratio, which is the total revenues divided by the fixed-price operating costs. This yields a figure of 35.51 million; given that $15.27 million comes from passenger revenue, the remainder is $20.24 million that is provided.
[j]Selden, A. There Is No Contest Between Corridors and Long Distance Trains: Long Distance Always Wins. United Rail Passenger Alliance, Jacksonville, FL, 2006. http://www.unitedrail.org/documents/20051231.html. Accessed December 1, 2006.
[k]Assuming a 4.5% inflation rate, those systems passenger-mile subsidies of $0.23, $0.24, and $0.20 (in 2006 dollars) would be $0.27, $0.29, and $0.24 (in 2010 dollars).

are accurate, (2) the costs are borne entirely by the public sector, and (3) the social costs per passenger mile suggested herein (3.4 to 55.3 cents) are agreed upon.

In a previous report (Virginia Department of Rail and Public Transportation, 2005), the concept of pilot service was suggested as one way of moving TDX service forward. There are benefits and risks to offering pilot service, and at this point in time there is insufficient information to determine whether pilot service would be productive. However, should this be an option Virginia and others wish to pursue, preliminary infrastructure and rolling stock cost estimates for such service are between $10 million and $31 million in 2010 dollars. This cost range of $10 million to $31 million is based on updating two types of costs in a study conducted 1 year ago: infrastructure costs and rolling stock costs (DRPT, 2005). As there are several assumptions in this range, it is indeed a preliminary estimate.

Recommended Action Plan

It may be the case that Virginia chooses to take no action on TDX at this time. Alternatively, Virginia may choose to study in greater detail whether TDX is a good investment of the Commonwealth's resources. Should Virginia choose the latter option, seven steps are offered for evaluating the implementation of TDX:

1. *Decide whether pilot service should be offered.* The 2005 report to the General Assembly proposed a pilot service that would operate between Bristol and Richmond by way of Roanoke and Lynchburg (Virginia Department of Rail and Public Transportation, 2005). The potential feasibility of this pilot project should be addressed in a comprehensive operational analysis. This analysis should look at the costs, ridership, and revenue for a range of service options, presenting the results as was done in Table ES1. For example, this report suggests that infrastructure and rolling stock investments for pilot service are between $10 million and $31 million, subject to a variety of assumptions—an estimate that a more detailed study might refine. The operational analysis should also compare the operational subsidy and the benefits to the public. For example, this study suggests a subsidy of $3.91 per passenger mile compared to benefits that are substantially less—but a more detailed study might yield different findings. Such a comparison may help decision makers determine whether the public benefit exceeds the public cost for the proposed service.

   (Steps 2 through 7 should be applicable to a pilot service or full service should either be undertaken.)

2. *Select a route and service levels for initial service*. Several alternatives exist; for example, providing service from Bristol to Washington could capture almost all (96%) of the TDX ridership (based on projected slow train times to Richmond); alternatively, service could be provided from Lynchburg to Washington at a reduced cost. (Table 8 suggests that 70% of TDX ridership might be between stations along the Lynchburg-Washington corridor.)

3. *Identify minimal infrastructure and rolling stock requirements*. The level of capital investments required will depend on the level of service being proposed. The estimated ridership for each route is not equal, so it may be feasible to select a route that maximizes the ratio of expected demand to cost. The impact of the Heartland Corridor Double-Stack Initiative and the I-81 Rail Corridor Study would also need to be considered.

4. *Develop a detailed ridership test for the service*. The test should compare projected to actual demand across four market segments: tourists, students, non-vehicle households, and business travel. One purpose of the test should be to relate service levels (time, frequency, reliability, and cost) to actual demand. As shown in Appendices B and C, it will be helpful to compare projected demand in each market segment and actual demand. Such comparisons between projected and actual

ridership levels might prove helpful when the Commonwealth is evaluating proposed passenger rail service and corresponding ridership forecasts in other situations.

5. *Investigate options for selecting an operator for the service*. Advantages exist for selecting Amtrak, Norfolk Southern, or a third party to operate the service. For example, Amtrak enjoys reduced maintenance of way and liability payments; Norfolk Southern may have advantages since it already operates freight service along its lines. (Maintenance of way payments reflect payments that Amtrak makes to Norfolk Southern in order to allow Amtrak to operate trains on Norfolk Southern lines.)

6. *Create an incentive structure for the operator to provide high-quality service*, as these have been used elsewhere to increase on-time performance.

7. *Identify possible funding sources for the service.* No source of funding readily addresses all of the TDX needs, even for a pilot service. However, some opportunities do exist that may help defray some of the costs. Two federal sources are the Railroad Rehabilitation and Improvement Financing (RRIF) Program, which provides loan opportunities, and the Congestion Mitigation and Air Quality (CMAQ) Program, which may offer a small opportunity. At the state level, funding sources include the non-federal portion of the secondary program (for counties) and the urban program (for cities), provided the Commonwealth Transportation Board approves, and Virginia's Rail Enhancement Fund (authorized by § 33.1-221.1:1.1 of the Code of Virginia). These latter two options (one being the urban or secondary program and one being the Rail Enhancement Fund) provide localities with an opportunity to contribute funds to TDX operation in the form of station construction subsidies, leasing rolling stock, or other infrastructure-related items. The Rail Enhancement Fund requires a 30% matching contribution from a non-state source such as the railroad, a regional authority, or a local jurisdiction.

These steps do not eliminate two critical challenges this study has not resolved. Because any service would operate on Norfolk Southern lines, detailed discussions need to take place between the Commonwealth and Norfolk Southern. In addition, the institutional issues highlighted remain: finding a dedicated funding source, setting an appropriate governance structure, measuring system performance, and determining the public and private benefits of proposed capital improvements.

INTRODUCTION

Enabling Legislation Requiring this Study

Item 438.B of HB 5002 in Chapter 3 Acts of Assembly (the Budget Bill for the 2006–2008 biennium) directs the Department of Rail and Public Transportation to provide updated information regarding the status of proposed passenger rail service between Bristol, Richmond, and Washington, DC (see Appendix A). This updated information includes (1) the status of the project that was initiated in accordance with the Virginia Transportation Act of 2000; (2) updated capital cost, operating cost, and revenue figures; and (3) the feasibility of the project to reduce roadway congestion in Virginia. Specifically, the Acts of Assembly state:

> The Department shall report to the Chairmen of the Senate Finance and House Appropriations Committees on the transportation project authorized under the Virginia Transportation Act of 2000 to provide passenger rail service between the Cities of Bristol and Richmond, and Washington, DC. In addition to the project's status, the Department shall include revised information on capital and operating costs, potential revenue of such passenger service, and the project's potential benefits to alleviate congestion on the state's Interstate and highway system of roads. The report shall be submitted by January 2, 2007 (Virginia General Assembly, 2006).

The General Assembly provided funds for related activities on two previous occasions: in 1996, $250,000 for a study of potential rail service to Bristol, and in 2000, as part of the Virginia Transportation Act, $9.337 million for capital projects (Virginia Department of Rail and Public Transportation, 2005).

Summary of Previous Studies

The feasibility of passenger rail service between Bristol and Washington, DC—hereafter referred to as the TransDominion Express, or TDX—has been studied five times in the past 10 years. Each study built on the previous one, but critical assumptions pertaining to service levels, cost, and ridership influenced the findings of each, as indicated in Table 1.

1. *House Document 51 in 1996* (Virginia Department of Rail and Public Transportation, 1996) concluded that service was feasible, noting, however, at least two unresolved issues. First, the study did not determine service times as it was a preliminary feasibility study, and second, the study noted that the potential conflict between freight service and passenger service, with each operating on the same lines owned by a private entity, needed further study. The second issue was later shown to be significant in a 2002 study by The Woodside Consulting Group, Inc. (Woodside Consulting, 2002), that identified necessary capital upgrades to facilitate rail service.

2. The *Frederic R. Harris, Inc., study in 1998* (Frederic R. Harris, Inc., 1998) projected ridership levels of 372,100 in the first year of operation, with ridership more than doubling by 2020—at which point no operating subsidy would be required. An initial capital investment of $9.3 million was identified with an initial subsidy of $10.8 million annually. Of significance is that the figures were based on the procurement of train technologies that through the use of tilting equipment can “maintain higher speed through curves” (presumably on existing track).

3. The *National Passenger Railroad Corporation (Amtrak) 2000 study* (National Railroad Passenger Corporation, 2000) indicated that although the 1998 study was credible in terms of its *relationship* between ridership and service levels, the service levels were not feasible for two reasons. First, the 1998 study had relied on "Talgo-type tilting coaches," which have a higher cant deficiency of 7 inches than current Norfolk Southern practice of 3 inches. *Cant deficiency* is described as the ratio of lateral and vertical forces transmitted by the rail vehicle while negotiating curved track. Second, the 2000 report noted that even with the higher cant deficiency, the 1998 speeds could not be attained on several curves. Accordingly, the 2000 study examined the service levels, ridership, and cost that could be achieved using existing technology under two scenarios: the modified plan (with the same two corridors) and an alternate plan (which added a Washington to Richmond corridor). The study could not determine the capital costs required for an improvement.

4. The *2002 Woodside Consulting* (Woodside Consulting, 2002) study was funded by DRPT at the request of Norfolk Southern to identify capital costs associated with implementing TDX service on Norfolk Southern lines. The study found that $120 million in capital costs were required, plus an additional $14.5 million for rail/highway crossings because of the additional passenger service. That study modified slightly the schedule of the Amtrak 2000 report but generally the two reports were similar regarding what constituted a feasible schedule.

5. *House Document 37* in 2005, prepared by DRPT (Virginia Department of Rail and Public Transportation, 2005), indicated that a $120 million capital investment (based on an estimate provided by Norfolk Southern) was required along with an annual operating subsidy of $14.5 million. No new ridership projections were given. The report also documented the feasibility of starting a pilot service—not to be confused with full service—which would require $24.5 million in capital costs and $9.1 million in operating costs and would entail longer service times than those shown in Table 1 (10 hours between Bristol and Richmond and 2.5 hours between Charlottesville and Washington, DC).

Examination of these studies also reveals institutional issues, apart from cost considerations, that require resolution for TDX implementation to be successful. Examples are (1) identifying a stable revenue stream for future years of service, (2) choosing an "appropriate governance structure" for the TDX service (Virginia Department of Rail and Public Transportation, 2005), (3) coordinating storage facilities between Norfolk Southern and the TDX operator, (4) identifying how improvements can be phased over time, (5) measuring the performance of the new system, and (6) determining public and private benefits of proposed capital improvements so that Norfolk Southern and the Commonwealth fund improvements in proportion to the level of benefit they receive.

Table 1. Summary of Previous Studies

Year	Author	Travel Time	Initial Ridership	Capital Investment	Annual Operating Subsidy[a]
1996	DRPT	Not given	520,000	$54 million	$22.3 million
1998	Frederic R. Harris, Inc.	7:27 (Bristol-DC) 6:47 (Bristol-Richmond)	372,100	$9.3 million	$10.8 million
2000	Amtrak (Modified)	8:37 (Bristol-DC) 2:25 (Lynchburg-Richmond)	26,252	Not stated	$14.5 million[b]
2000	Amtrak (Alternate)	8:20 (Bristol-DC)[c] 2:38 (Lynchburg- Richmond)[c] 2:10 (Richmond-DC)[c]	40,750	Not stated	$ 9.4 million[b]
2002	Woodside Consulting	9:52 (Bristol-DC) 2:55 (Lynchburg- Richmond)	Not given	$120 million[d]	Not given
2005	DRPT	8:18 (Bristol-DC) 7:45 (Bristol-Richmond)	Not given	$120 million	$14.5 million[b]

[a]Based on the first full year of service.
[b]Does not include equipment maintenance costs, which are given as $6.9 million.
[c] Travel times are approximate and vary by time of day.
[d]Does not include $12.0 million in necessary improvements to at-grade rail crossings.

Effort Required for the 2006 Update

The variation in the studies shown in Table 1 suggests which aspects of the TDX implementation require the most effort. Four critical aspects were emphasized in the current study:

1. *The capital costs need to be updated to a common forecast year.*

2. *The ridership estimates need to be updated.* Previous estimates were based on the feasibility of using tilting technology and/or other technologies and the sensitivity of ridership to these changes in service levels.

3. *With updated ridership estimates, the resultant revenue, the expected operating subsidy, and the expected traffic that may be diverted from congested facilities need to be determined.*

4. *Given that previous studies noted institutional issues, an action plan needs to be developed that suggests how to proceed in a phased but productive direction should a pilot effort be initiated.*

CAPITAL COST UPDATE

The base capital cost of $120 million was first identified in 2001 (Woodside Consulting, 2002). The documents providing this cost appear to be detailed (e.g., a $30,000 cost estimate is provided for relocating an industrial turnout between the Montview and Kinney Yards at the Lynchburg station [Attachment G-7]). However, such a cost was presumably in 2001 dollars and thus may not reflect inflation since that time.

The $120 million entails 22 construction projects (Woodside Consulting, 2002):

- $40.5 million comprise improvements on the Alexandria-Lynchburg line (e.g., extension of the runaround track at Springfield, construction of a third main track near Manassas, construction of a bypass main track at Lynchburg)

- $57.4 million comprise improvements on the Lynchburg-Bristol line (e.g., track work, signal work, and grading near Liberty; construction of a crossover near Montgomery; construction of a bridge near Montvale)

- $22.1 million comprise improvements on the Lynchburg-Richmond line (e.g., rehabilitation of track and signal for the South Richmond Terminal).

Generally the improvements required some combination of track construction, signal work, grading, or bridge work; a few projects entailed acquisition of a relatively small amount of right of way.

The American Association of Railroads (2006) publishes several railroad price indexes that show how inflation has affected various goods and services provided by the railroads. The index most appropriate for the $120 million cost estimate is entitled "Materials, wage rates, and supplements combined (excluding fuel)." The index shows the impact of inflation on various materials and wages (which would be appropriate for the construction improvements identified in the 2002 study (Woodside Consulting, 2002)) but excludes the increase in fuel cost (which affect railroad operations but not improvements to the track). Because the $120 million shown is generally not broken down into the cost of labor and materials, it is not appropriate to use more detailed indices that distinguish between an inflated labor cost and an inflated materials cost. Table 2 shows these railroad cost indices for 2001 and 2005.

Table 2. Cost Indices Used in This Study

Index	Applies to	Year 2001	Year 2005	Average Annual Change (%)
Railroad Index[a]	Rail construction	315.7	356.8	3.11
Highway Index[b]	At-grade rail highway crossings	144.8	183.6	6.11
Consumer Price Index[c]	All goods and services	177.1	195.3	2.48

[a]Source: American Association of Railroads, 2006 (materials prices, wage rates, and supplements combined, excluding fuel).
[b]Source: Federal Highway Administration, 2006a (Federal-Aid Highway Construction Composite Index).
[c]Source: Bureau of Labor Statistics, 2006 (Consumer Price Index for each year).

Thus, the $120 million in capital costs (in 2001 dollars) may be estimated as approximately $136 million in 2005 dollars using Eq. 1.

$$\text{Estimate in 2005 dollars} = (\text{Estimate in 2001 dollars})\frac{2005\ \text{index}}{2001\ \text{index}} \qquad \text{(Eq. 1)}$$

$$\text{Estimate in 2005 dollars} = (\$120\ \text{million})\frac{356.8}{315.7} = \$135.6\ \text{million}$$

The 2002 study (Woodside Consulting, 2002) also identified $12 million in track improvements that would be needed to sustain the higher speeds at which Amtrak trains would travel. This $12 million in upgrades (such as superelevation) may be represented as $13.6 million in 2005 dollars, using same approach as that indicated by Eq. 1.

Finally, the 2001 study identified $12.6 million in at-grade highway-rail crossings that would need modification. Construction costs, however, have also increased since 2001 owing somewhat to the price of fuel; for example, the *highway* construction cost composite index has risen by almost 31% since year 2001 (Federal Highway Administration [FHWA], 2006a). The implication of this increase is that the $12.6 million figure may also need updating. Using the same approach as shown in Eq. 1, the $12.6 million (in 2001 dollars) is inflated to $16.0 million (in 2005 dollars) using the highway index from Table 2.

Thus, total capital costs are estimated as $165.2 million in 2005 dollars. Although Table 2 shows that highway costs increased at more than twice the rate of inflation and that rail costs increased slightly more than the rate of inflation, it is not possible to determine if this trend will continue. Table 3 presents suggested inflated costs by future years based on a midrange annual estimate of 4.5%. This rate is higher than the current rate of inflation (3.8% between the first half of 2005 and the first half of 2006), and somewhat higher than the rail index, but is lower than the highway index. For example, if funds cannot be programmed until 2009, Table 3 suggests that improvements will cost $197 million in 2009 dollars.

Table 3. Estimated Capital Costs (in millions) in Current Year Dollars[a]

Year[b]	2005	2006	2007	2008	2009	2010
Cost	$165.2	$172.6	$180.4	$188.5	$197.0	$205.9

[a]Includes both rail improvements and improvements to rail and highway crossings.
[b]Assumes prices increase by 4.5% annually.

OPERATING COST AND OPERATING REVENUE UPDATES

Table 1 shows that the annual ridership forecasts by previous studies have differed by more than an order of magnitude. To update these forecasts, therefore, it was necessary to (1) understand the reasons for disparate ridership projections in previous studies, (2) determine how ridership today might be affected by service levels (e.g., train frequency, travel time, cost, and amenities), (3) determine the service levels that a provider could offer, and (4) estimate the ridership that would result.

Reasons for Disparity in Ridership Projections Among Previous Studies

In 1998, the Frederic R. Harris, Inc., study projected an initial ridership of 372,100 in the year 2000. However, a 2000 Amtrak study estimated an initial ridership of 26,252 in the year 2005 (National Railroad Passenger Corporation, 2000). A fundamental reason for the disparity in ridership projections is that the studies used different technologies and different service levels to estimate ridership (Drew Galloway, Personal Communication, September 29, 2006).

In the 2000 study, Amtrak assumed that Virginia would make some investment to increase passenger capacity, but it did not assume any investment in technology to reduce trip times (Drew Galloway, Personal Communication, September 29, 2006). Thus, the study's lower ridership projections (as compared to the 1998 Frederic R. Harris study) are due, at least in part, to the 2000 study presuming slower train service than that presumed in the 1998 study.

Although the Amtrak study (2000) assumed that service level technology would be static, the Frederic R. Harris, Inc., study (1998) assumed that the rail cars used for passenger service would be equipped with tilt and steerable wheel technology. When train cars are incorporated with this technology, the train is able to navigate curves safely at higher speeds, thereby reducing trip times. The amount of the reduction in trip times depends in part on the frequency of track curves, but tilt technology can result in a reduction of travel time of up to 20% by allowing the train to travel 5 to 20 mph faster without sacrificing safety levels and without investments in the track (Drew Galloway, Personal Communication, September 29, 2006). However, this number represents a best case scenario. For example, when Amtrak Cascades began leasing rail cars equipped with tilt technology in 1994, service times from Portland to Seattle dropped by 10% (Ken Uznanski, Personal Communication, October 4, 2006). Still, the decrease in service time inevitably makes passenger rail service more competitive with trips in a private passenger automobile and, hence, leads to increased ridership.

Although tilt technology results in reduced travel times, two obstacles may prevent the technology from being a viable option in Virginia.

1. *The lack of a critical mass of purchasers for tilt-equipped rail cars.* One Amtrak representative noted that few states invest in intercity rail service and the few that do often choose the cheaper option of using existing equipment over investing in newer technologies (Drew Galloway, Personal Communication, September 29, 2006). Since demand for tilt-equipped rail cars remains low, manufacturers of the cars are not able to achieve significant economies of scale, making the per unit cost of the cars prohibitively expensive for production (Drew Galloway, Personal Communication, September 29, 2006). The manufacturer (Talgo) suggests that a rough cost estimate for a 12-car trainset would be $15 million to $20 million (not including the locomotive) but cautioned that each project is different (Antonio Perez, Personal Communication, October 30, 2006). The manufacturer also noted that states that have "shown interest" in this technology are Illinois, North Carolina, Pennsylvania, and Wisconsin (along with Washington, which uses the technology on its Amtrak Cascades line as noted previously). A North Carolina operator noted that modern tilt equipment such as Talgo will probably not be feasible outside its current use in the Northwest until there is a critical mass of purchasers, which the operator estimated to be about 30 trainsets (Patrick Simmons, Personal Communication, October 2, 2006).

2. *Possible additional maintenance requirements.* In Virginia, freight railroads own all of the routes needed for TDX passenger service, and uncertainty exists regarding whether and how much the use of tilt-equipped rail cars would increase their maintenance costs (Drew Galloway, Personal Communication, September 29, 2006). The manufacturer noted that Talgo trains do not require any special track for

operations (Antonio Perez, Personal Communication, October 30, 2006) but that "information regarding desired trip times and condition of the tracks would be needed to give . . . an exact answer" about the feasibility of using such equipment in Virginia (Nora Friend, Personal Communication, October 30, 2006).

A five-way discussion involving the Commonwealth, the freight rail owner, the passenger service operator (should the operator not be Norfolk Southern), the Federal Railroad Administration (FRA), and the manufacturer will be needed to determine whether modern tilt equipment is viable on Virginia facilities. If these discussions occur, they will be most helpful to Virginia if the Commonwealth has a clear understanding of how improved travel time will affect ridership. Thus, knowing the sensitivity of ridership to service is a precursor for such discussions.

Sensitivity of Ridership to Service Levels

Table 4 shows the travel times and ridership levels in each Virginia study that provided both pieces of information. It is possible that differences in travel times alone do not explain the differences in ridership; for example, it would seem unlikely that an 11% increase in the travel time from the Frederic R. Harris study (1998) to the Amtrak study (2000) would result in a 93% drop in ridership. This disparity does not make one study more correct than another, but it does show that different assumptions regarding market demand can influence these projections.

Elsewhere, reliable estimates of the impact of changing travel time alone have been difficult to discern in isolation. For example, in the Amtrak Cascades—a line between

Table 4. Detailed Comparison of Train Schedules Shown in Previous Studies (Trains per Day in Parentheses) [Ridership Forecasts in Brackets]

Segment	Location	Frederic R. Harris (1998)[a]	Amtrak Modified (2000)[b]	Amtrak Alternate (2000)[b]	Woodside Consulting (2002)
Bristol to DC	Bristol to Lynchburg	4:09 (2) [20,133]	4:47 (2)	4:47 (1)	6:17 (1)
	Lynchburg to DC	3:16 (2) [158,972]	3:29 (2)	3:29 (2)	3:29 (2)
	Total	7:44 (2)	8:37 (2)	8:18 (1)	9:52 (1)
Lynchburg to Richmond		2:25 (2) [16,617]	2:41 (2)	2:41 (1)	2:55 (2)
Richmond to DC		6:47 (2) [178,678]	7:11 (2)	2:14 (1)[c]	10:15 (1)
Total ridership		[374,400]	[26,252]	[40,750]	[not given]

[a]Based on the most conservative projection in the 1998 study: 374,400 total riders at fares equal to $0.30 per mile. The total station boardings and alightings were used to develop a proportion of the 374,400 riders attributable to each line. Stations whose ridership served multiple lines were split by a simple proportion: e.g., because Lynchburg could theoretically serve the Bristol to Lynchburg, Lynchburg to DC, and Lynchburg to Richmond lines, the station's contribution to each segment was one-third.
[b]National Railroad Passenger Corporation, 2000. Ridership forecasts for individual segments were not available for this study. This study had two forecasts: one called the modified plan and one called the alternate plan.
[c]Unlike the other segments, this service would operate on track owned by CSX.

Vancouver, British Columbia; Seattle, Washington; and Portland, Oregon—ridership increased from approximately 94,000 in 1993 to almost 590,000 in 2003, almost 6-fold (Washington State Department of Transportation [WSDOT], 2004).

Part of this increase is due to an increase in the frequency of the Seattle-Portland service, i.e., one train in 1993, two trains in 1994, three trains in 1998 (WSDOT, 2004), and four trains sometime thereafter (Ken Uznanski, Personal Communication, October 4, 2006). However, WSDOT reports that seven factors explain the increase in ridership: "increased train frequency; reduced train travel times; increased traffic congestion; customer service improvements; smart, local marketing and promotion; custom-built Talgo trains; and station improvements" (WSDOT, 2004).

Similarly, between 1998 and 2005, the Capital Corridors line saw a tripling in frequency (from 8 daily trains in 1998 to 24 daily trains in 2005) and an almost corresponding tripling of ridership (from 463,000 to more than 1.2 million during the same period) (Capitol Corridor Joint Powers Authority [CCJPA], 2005). However, the CCJPA report explains that several initiatives improved ridership, such as improved stations, better amenities, and other services. A substantive portion of the change in ridership demand was due to increases in service levels, defined for the facility as frequency, travel time, and reliability. Additional amenities also affected ridership, such as a pair of outlets for every seat for increasingly prevalent laptop use, flip-down tray tables, a staffed food service car, and a wider seat pitch (39 inches as opposed to 29 to 31 inches) (Eugene Skoropowski, Personal Communication, October 20, 2006).

North Carolina operates a 180-mile Piedmont line between Raleigh and Charlotte, and train travel times have dropped from about 4 hours 5 minutes in 1990 to about 3 hours 7 minutes at present, with automobile travel time remaining constant at approximately 3 hours (Patrick Simmons, Personal Communication, October 2, 2006). Over that same period, ridership appears to have doubled, from under 300,000 to almost 600,000. However, other factors are at play. For example, ridership increased only slightly from 2001 to 2005 (about 20,000 riders) (Patrick Simmons, Personal Communication, October 2, 2006; see graph entitled "NC Intercity Rail Passenger Ridership") whereas train travel times dropped from 3 hours 45 minutes to 3 hours 7 minutes over the same period (Patrick Simmons, Personal Communication, October 2, 2006; see graph entitled "Raleigh-Charlotte Travel Time in Minutes"). It was also suggested (Patrick Simmons, Personal Communication, October 2, 2006) that targeted pilot service can introduce new riders, some of whom may continue to use the regular service even after the pilot service has been cancelled, which did occur with the Piedmont system.

The Northern New England Passenger Rail Authority (NNEPRA) supports the Amtrak Downeaster, a line between Portland, Maine, and Boston, Massachusetts, which began operations in 2001. Annual ridership in 2002 and 2005 was similar (approximately 292,000 and 294,000, respectively), with a dip in the intervening years (258,000 and 249,000) (Douglass, 2005). In May 2005, the travel time from Portland to Boston was reduced to 2 hours 30 minutes from 2 hours 45 minutes, and this drop was suggested as the reason for a 47% increase in ridership in September (Northern New England Passenger Rail Authority, 2005). However, a customer service survey (Northern New England Passenger Rail Authority, 2005) suggested that

other service aspects (such as on-time performance) and amenities (quality food service and friendliness) are also important for attracting ridership.

The literature does provide information on the elasticity of ridership changes in service levels but much of these data in the United States are based on urban transit systems. (*Elasticity* is roughly the percentage change in ridership divided by the percentage change in service.) Limited data regarding commuter rail systems suggest wide variability: e.g., in Philadelphia, a calculated 9.2% improvement in service yielded an 8.6% increase in ridership, but in Boston, a 77% improvement in service yielded a 37.5% increase in ridership (Evans, 2004). Evans noted that changes in addition to service were made, however, such as marketing and fare discounts; further, it was suggested that service improvements on longer routes have a greater impact on demand than do service improvements on shorter routes. The literature also supports the observation that customer service, in the form of food/beverage service and on-board amenities, is a significant influence on demand for intercity passenger rail (Perl, 2000).

Finally, it has also been suggested by a practitioner that caution should be exercised when evaluating any forecast that is not based on historical data, as some forecasts may not be accurate. For example, a few decades ago, the Joint Regional Transportation Committee concluded that daily ridership for the Boston Commuter Rail System should not exceed 50,000 because of the free-flowing Massachusetts Turnpike (Eugene Skoropowski, Personal Communication, October 20, 2006). In practice, the line went from a daily ridership of approximately 20,000 passenger trips to more than 140,000 (Eugene Skoropowski, Personal Communication, October 20, 2006). This view is supported by the literature, e.g., FRA in 1977 predicted a ridership of 14.7 million passengers in the Northeast Corridor as a result of service improvements, but ridership grew to only 9.8 million (Vaca, 1993). Part of the reason was that travel times were slower than expected, but part of the reason was modal competition, such as the low-cost People's Express airlines at the time. Based on experience in the rail transit area, Vaca stated that forecast errors are most likely to be greatest when a facility has not been built (as opposed to how service improvements will affect ridership on an existing facility).

Interestingly, the Safe Accountable Flexible Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) does require the Federal Transit Administration (FTA) (through the Secretary of Transportation) to "analyze, evaluate, and consider the reliability of the forecasting methods used by New Starts project sponsors and their contractors to estimate costs and ridership" (Government Accountability Office [GAO], 2006). New Starts projects are projects FTA uses to select transit projects for funding. In January 2006, FTA proposed two procedural changes that would affect how it evaluates New Starts projects (GAO, 2006): (1) ridership and cost uncertainties must be explicitly analyzed, and (2) the technical methods used for forecasting must be certified. Because of concerns expressed by transit community members, such as a lack of guidance regarding how to characterize uncertainty and the fact that forecasts are often generated by multiple parties, FTA did not adopt the changes. It is clear at the national level that the concern about forecast reliability is real but there are obstacles to performing before-after comparisons of projected and actual forecasts.

The Service Levels a Provider Might Offer

A previous study characterized freight traffic on various Norfolk Southern lines as ranging from light to heavy (National Railroad Passenger Corporation, 2000). DRPT staff have noted that two current freight rail initiatives—the Heartland Corridor Double-Stack Initiative and the I-81 Rail Corridor Study—could result in improvements that will divert some freight from truck to rail. Although these initiatives may reduce congestion on highway facilities, they will logically increase congestion on freight facilities and thus *increase* freight traffic on most segments of TDX provided in Table 5. The segment that should be the least affected would be between Richmond and Lynchburg: i.e., freight will increase on that segment but the increase should not be as great as the increases on the segments between Bristol and Washington, DC.

Table 5. Current Freight and Passenger Service on Proposed Segments of TDX[a]

TDX Segment	Location	Freight Traffic
Lynchburg to Richmond	Richmond to Burkeville	Very light
	Burkeville to Lynchburg	Moderate
Bristol to Lynchburg	Lynchburg to Roanoke	Moderate
	Roanoke to Walton	Heavy
	Walton to Bristol	Moderate
Lynchburg to DC	Lynchburg to Manassas	Heavy + Amtrak service
	Manassas to Alexandria	Moderate + commuter/Amtrak service
	Alexandria to DC	Heavy, lines used by CSX, Norfolk Southern, and Commuter/Amtrak service (more than 80 trains per day)

[a]Excerpted from National Railroad Passenger Corporation. *Rail Passenger Service Study: Richmond, VA/Washington, D.C. to Bristol, VA*, 2000 (no city given). The reader may obtain a copy of this report by contacting the Virginia Department of Rail and Public Transportation, Richmond, Virginia.

Figure 1. Proposed TDX Service. *Source:* Virginia Department of Rail and Public Transportation, 2005; annotation added by authors.

At this point in time, the final 2002 schedule provided for Norfolk Southern (Woodside Consulting, 2002) is appropriate as a starting point for estimating ridership. Conversations with Amtrak staff suggest that the conservative schedule from the 2002 Norfolk Southern study (Woodside Consulting, 2002) was feasible then, although the aforementioned changes in freight due to the I-81 Rail Corridor Study and the Heartland Corridor Double-Stack Initiative may render that schedule difficult to achieve.

Estimate of Potential Ridership

Whereas previous studies gave total forecasts, it was not always possible to determine more detailed ridership numbers on individual segments. Therefore, current population and employment data were used to determine the *potential* ridership between each pair of stations as shown in steps 1, 2, and 3 that follow. This potential ridership does not mean all such persons will use rail—rather, only a fraction of those individuals will choose rail service. The size of the fraction depends on the service levels that are provided, as shown in steps 4 and 5.

Appendix B details the methodology for estimating this potential ridership and provides an example of the calculations. The methodology may be summarized as follows:

1. *Determine the number of potential non-business trips*. These include trips generated by college students, tourists, and non-vehicle households. To determine these trips, it was assumed that a TDX station was accessible to any population, college, or tourist sites in the same city or surrounding county as the station.

2. *Select a total of six stations for further analysis, with at least one station from each region*. Generally the stations with the highest ridership were chosen. The six stations with the highest ridership and that spanned the entire TDX network were Alexandria, Charlottesville, Lynchburg, Radford, Richmond, and Roanoke. In this study, these six stations generated an estimated 90% of the ridership. (Alexandria was used instead of Washington, DC, as it was more compatible with the Virginia-based data set. However, this decision may underestimate the number of potential travelers to points in Maryland or Washington, DC.)

3. *Estimate the total potential non-business ridership between each pair of stations*. As detailed in Appendix B, the gravity model was used to estimate the ridership between each station pair. For example, given the distance between Richmond and Lynchburg, the number of potential riders in Richmond and Lynchburg, and the number of tourist sites and colleges at each station, a total of 55,233 trips exist from one station to the other on an annual basis. These trips are reported in Table 6.

4. *Repeat steps 1 through 3 to determine business ridership*. A comparable approach was used to determine business ridership with one exception: the number of potential business riders (step 1) was based on journey to work travel available from the county to county worker flow files provided by the U.S. Census (U.S. Census Bureau, 2003). These trips are reported in Table 7.

5. *Determine the sensitivity of non-business demand for rail as a function of travel time*. Most previous studies gave only total ridership forecasts. However, information from the study by Frederic R. Harris, Inc. (1998) may be used to determine how changes in service time should affect demand. This information was used to develop an equation relating increases in train travel time to decreases in service, as shown in step 5 of Appendix B and as detailed in Appendix C. Then, the schedules provided to Norfolk Southern in January 2002 (Woodside Consulting, 2002) were used to determine service times, and from these schedules, ridership was estimated on each segment.

Table 6 shows the result of steps 1 through 3 (the potential non-business ridership), and Table 7 shows the result of step 4 (the potential business ridership). To increase transparency, however, individual results of each step are given in Appendix B and full details of each prediction are shown in the accompanying spreadsheet at http://www.vtrc.net/tdxexpress.

Table 6. Total Potential Non-Business Passenger Trips per Year Between Stations[a]

	Radford	Roanoke	Lynchburg	Charlottesville	Alexandria	Richmond
Radford	--	39,045	9,819	7,423	89,261	30,472
Roanoke	39,045	--	30,855	16,579	164,163	65,366
Lynchburg	9,819	30,855	--	16,785	143,714	55,233
Charlottesville	7,423	16,579	16,785	--	234,962	104,196
Alexandria	89,261	164,163	143,714	234,962	--	1,458,925
Richmond	30,472	65,366	55,233	104,196	1,458,925	--

[a]These include vehicle trips and train trips: it is expected that most, or all, of these will be vehicle trips.

Table 7. Total Potential Business Passenger Trips per Year Between Stations[a]

	Radford	Roanoke	Lynchburg	Charlottesville	Alexandria	Richmond
Radford	--	604,200	16,500	12,450	34,500	23,100
Roanoke	604,200	--	74,400	5,850	4,500	15,600
Lynchburg	16,500	74,400	--	63,750	9,750	30,300
Charlottesville	12,450	5,850	63,750	--	30,450	121,200
Alexandria	34,500	4,500	9,750	30,450	--	141,300
Richmond	23,100	15,600	30,300	121,200	141,300	--

[a]These include vehicle trips and train trips: it is expected that most, or all, of these will be vehicle trips.

Table 8 shows the predicted train ridership assuming service levels comparable to that shown in the 2002 report performed for Norfolk Southern and DRPT (Woodside Consulting, 2002). As detailed in Appendix C, previous studies suggested at least four travel demand functions that could be applied to the data set; i.e., if two studies both assume the train is 10% slower than travel by auto, each study might still suggest a different ridership level because of differences in their sensitivity of ridership to travel time. For this study, four travel demand functions were generated and the highest and lowest forecasts from each were used to generate the ranges shown in Table 8. Under the most optimistic scenario, the six stations shown could serve 51,985 annual passenger trips; the most pessimistic scenario suggests a figure of 12,806 passenger trips. Recognizing that the six stations captured about 90% of the riders, the range of annual passenger trips may be increased by about 10% to be from about 14,000 to 58,000.

Table 8. Total Predicted Train Passenger Trips Between Stations

	Radford	Roanoke	Lynchburg	Charlottesville	Alexandria	Richmond
Radford	--	0 to 301	0 to 29	0 to 14	0 to 910	0 to 14
Roanoke	0 to 262	--	0 to 1849	0 to 202	0 to 3,446	0 to 41
Lynchburg	0 to 34	0 to 2,290	--	1,235 to 3,228	1,919 to 5,639	0 to 1051
Charlottesville	0 to 13	0 to 162	859 to 2,785	--	3,737 to 10,244	0
Alexandria	0 to 748	0 to 3,194	1,556 to 5,212	3,498 to 9,964	--	0
Richmond	0 to 17	0 to 51	0 to 1051	0	0	--

The forecasts shown in Table 8 are probably most useful as rough indicators of where demand may start to peak; e.g., it appears from Table 8 that demand between Charlottesville and Alexandria might be relatively large. They also may serve as a benchmark for comparing projected and actual ridership. However, the collective advice from the literature and experiences of several operators should not be ignored: (1) for any new service, experience has shown that demand forecasts are quite likely to be in error (Vaca, 1993); (2) there can be different changes in passenger demand to a change in service levels (Evans, 2004); and (3) other factors besides service levels influence demand, such as amenities and customer service (Northern New England Passenger Rail Authority, 2005; Perl, 2000; Washington State Department of Transportation, 2004). Unfortunately, the numbers in Table 8 are not exempt from this trend.

Operating Cost Update

The best information available regarding operational costs for full service (National Railroad Passenger Corporation, 2000) suggested the operating costs in Table 9 in FY 2005 dollars.

Tables 6 and 7 affect the ridership and resultant revenue projections, but the operating costs in Table 9 should be driven by the type of service offered. Presuming that there are two full service trains between all stations—e.g., the more expensive service offered as shown to the left of Table 9—in FY 2010 dollars the operating costs should be about $19 million. Presuming revenue of $0.20 per mile (in 2005 dollars) or $0.25 per mile (in 2010 dollars) and an average 127-mile trip length, a low-end ridership (14,000) should generate slightly more than $0.44 million annually. A high-end ridership (58,000) should generate slightly more than $1.84 million annually.

Table 9. Summary of Cost Information in 2005 Dollars[a]

	Modified Plan	**Alternate Plan**
Characteristics	**Two round trips daily to all stations**	**Two round trips between Washington and Lynchburg only. One round trip for all other stations.**
Operating Cost	$15.27 million	$10.54 million
Revenue	$0.81 million	$1.17 million
Ridership	26,252	40,750

[a]National Railroad Passenger Corporation, 2000.

Accordingly, assuming an operating cost of $19 million and revenues between $0.44 million and $1.84 million, an annual operating subsidy of between $17.16 million and $18.56 million in FY 2010 dollars will be required. (Alternatively, it may be said that the best estimate of the subsidy required will be the average of the low and high subsidies, which is $17.857 million—a figure used in Table ES1.)

CONGESTION REDUCTION BENEFITS

Some highways that parallel the proposed TDX, such as Route 29 in Nelson County, are relatively uncongested; thus, congestion reduction benefits at those locations are minimal. Some heavily traveled areas, however, would be served by TDX. For example, Route 29 in Prince William County carried approximately 48,000 vehicles *per day* in 2005 between the Fauquier County Line and U.S. 15 (Virginia Department of Transportation, 2005). The upper end of the ridership on the entire TDX is projected to be just slightly greater for the *entire year*. Under the most optimistic forecast, TDX might take approximately 125 vehicles from the section on a daily basis—thus, it is critical not to overstate the benefits of TDX in terms of congestion reduction.

It should be clarified that one reason for TDX not offering as many congestion-reduction benefits as might otherwise be anticipated is that some of these highway facilities may have substantially more local trips than through trips. For example, Table B1 in Appendix B suggests that TDX may offer faster travel time than the automobile. Thus, a substantial portion of the total trips between Charlottesville and Alexandria might ultimately be by rail rather than by automobile. However, the total number of annual trips by all modes between Charlottesville and Alexandria is estimated as slightly more than 0.5 million per year (based on summing trips between these two cities from Tables 6 and 7) which might be slightly more than 2,000 per day. This figure of 2,000 is substantially less than the daily existing traffic volume on Route 29 (of 48,000) noted previously.

AN APPROACH FOR COMPARING TDX BENEFITS AND COSTS

The congestion-reduction potential of TDX does not obviate the benefits of TDX providing an alternative mode of transportation for specific market segments, such as tourists, students, and non-vehicle households. For example, the literature suggests that motor vehicle use exacts an unpaid social cost in the form of crashes, energy, noise pollution, air pollution, parking, user costs, and infrastructure investments, with figures ranging from 3.4 cents per passenger mile to as high as 55.3 cents per passenger mile (Meyer and Miller, 2001). This range appears to encompass social costs that others have proposed; for example, the Santa Cruz County Regional Transportation Commission suggests an unpaid social cost of 33 cents per passenger mile (Santa Cruz County Regional Transportation Commission, undated). Assuming that the presumably 2006 figure were inflated to 2010 dollars, the inflated cost (39 cents per passenger mile) is still within the range proposed by Meyer and Miller (2001). One possible way of determining whether TDX benefits justify a public investment is to compare this range of social costs to the operating subsidy required.

In Table ES1, an operating subsidy of $3.91 per TDX passenger mile was noted. Thus, even assuming that (1) every TDX passenger mile replaces an automobile passenger mile, and (2) the highest automobile social cost per mile from the literature of 55.3 cents is chosen (Meyer and Miller, 2001), the cost of TDX would not justify the investment. This finding could change, however, if any of the following were to occur:

- the costs to the public sector of TDX were reduced by sharing the costs (e.g., in the form of a public-private partnership). The estimate for the public subsidy in Table ES1 was $17.857 million.

- TDX ridership were to rise beyond the level of 36,000 riders shown in Table ES1

- the social costs of automobile travel were estimated to be higher than the upper value from the literature of 55.3 cents per automobile passenger mile (Meyer and Miller, 2001).

For example, if the TDX subsidy were to remain the same as shown in Table ES1 ($17.857 million) but the ridership changed from 36,000 to 256,000—7 times higher than what was forecast in Table ES1, with an average trip length of 127 miles, the subsidy per mile would be $17.857 million divided by the product of 256,000 riders and 127 miles, which yields about 55 cents per passenger mile. This figure simply illustrates the sensitivity of Table ES1 to the various assumptions, and for clarification, the estimate in this report is that TDX would require a subsidy of about $3.91 per passenger mile.

Given the variation in demand between station pairs shown in Table 8 and possible variation in capital costs required to accommodate passenger service between these station pairs, it is possible that certain corridors of TDX might have a higher ratio of ridership to costs (and thus require a lower subsidy per passenger mile) than other corridors. Thus, should alternative service levels or alternative service routes be proposed than those discussed here, they could be compared to an agreed-upon social cost per mile of automobile use.

POSSIBLE ACTION PLAN AND LIMITATIONS

If Virginia's General Assembly desires to move the TDX project forward, there are several options for doing so. One option, in the form of an action plan, is presented here and includes the following seven steps:

1. Decide whether pilot service should be offered.
2. Choose a corridor for service.
3. Identify minimal infrastructure and rolling stock requirements for service.
4. Develop a detailed ridership test for service.
5. Investigate options for selecting an operator for full service.
6. Create an incentive structure for that operator to provide high-quality service.
7. Identify possible funding sources for full service.

Decide Whether Pilot Service Should Be Offered

Implementation of *full* TDX passenger service carries two risks for the Commonwealth: first, the capital costs mentioned previously (about $206 million in 2010 dollars) might divert resources that could have been spent more effectively on other transportation projects, and second, if the service is poorly managed, an opportunity to test another mode of transportation (rail passenger service in the Bristol/Washington, DC, and Lynchburg/Richmond corridors) will be lost.

The literature suggests that one approach for managing these risks is to stage projects such that long-term and short-term alternatives that "do not foreclose future options" are periodically considered (Meyer and Miller, 2001). Implementation of *pilot* TDX passenger service carries the same two risks, but a pilot effort reduces their magnitude substantially. For example, in 2005, Norfolk Southern proposed one option for pilot service as being a single round trip train between Bristol and Richmond (Virginia Department of Rail and Public Transportation, 2005). This option reduces the two risks by approximately 80%: the capital investment required would be between $20 million and $23 million (in 2010 dollars) and only 13% of the potential ridership would be tested based on the figures in Table 10.

Table 10. Options for Phased Passenger Service Based on 1 Year of Operation

Initial Corridor	Proportion of Total Demand on Corridor[a]	Advantages
Bristol to Richmond	13%	Connects state capital to most rural portion of Virginia.
Bristol to Alexandria	96%	Connects most rural portion of Virginia to nation's capital (Alexandria station would enable access to Washington, DC)
Roanoke to Alexandria	91%	Heavy population between city pairs most likely to generate demand; track east of Radford has fewer changes in grade.
Lynchburg to Alexandria	70%	Addresses a majority of rail trips from Table 8 with a smaller service investment.
Charlottesville to Alexandria	38%	Addresses a substantive portion of rail trips from Table 8 with a smaller service investment.

[a]Proportions are based on the upper range of forecasted riders shown in Table 8. For example, of 52,751 annual riders, approximately 6,990, or 13%, would be traveling on stations between Richmond and Bristol, based on summing the ridership between the following station pairs: Richmond-Radford, Richmond-Roanoke, Richmond-Lynchburg, Roanoke-Radford, Radford-Lynchburg, and Roanoke-Lynchburg).

Choose a Corridor for Service

There are several phasing options for passenger service, and each has its own advantages as noted in Table 10. Table 10 suggests that demand is not uniform along each segment of the TDX, for example, stations between Lynchburg and Alexandria generate more rail trips than stations between Lynchburg and Richmond (based on the service levels used for this study). The feasibility of all phasing options shown in Table 10 are affected by two initiatives—the Heartland Corridor Double-Stack Initiative and the I-81 Rail Corridor Study, both of which if they shift freight traffic from trucks to rail will affect the feasibility of passenger operations.

Identify Minimal Infrastructure and Rolling Stock Requirements for Service

Although Norfolk Southern suggested costs for a pilot service (Virginia Department of Rail and Public Transportation, 2005), these costs will need to be updated based on (1) the selection of the pilot route and (2) the completion of the Heartland Corridor Double-Stack Initiative and I-81 Rail Corridor Study. For example, it has been suggested that although the Norfolk Southern lines have been upgraded east of Radford since the Civil War, this has not been the case for the lines [south]west of Radford (Drew Galloway and Jeff Mann, Personal Communication, October 13, 2006). Although making such upgrades was common between 1900 and 1930 to accommodate heavier freight trains, "the line [south]west of Radford still has a lot of sharp curves" and follows the original alignment—thereby necessitating slower speeds [on the track where TDX service would be offered, between Bristol and Radford] (Drew Galloway, personal communication, December 11, 2006). Thus, if pilot service were offered, it might well be the case that the costs could be reduced by offering service from Washington, DC, just to Radford rather than all the way to Bristol. Table 11 presents suggested costs based on information that could be extracted from the 2005 report (DRPT, 2005) with costs converted into 2010 dollars, although clearly the aforementioned Heartland Corridor Double-Stack Initiative and I-81 Rail Corridor Study may affect these costs.

Reliable rolling stock would need to be procured to operate any service. Options of leasing railcars and locomotives should be investigated. For example, if a decision were made to offer only a pilot service and to defer the decision to offer full service, leasing would be a means of obtaining rolling stock for the pilot service without a long-term purchase commitment.

Table 11. Costs for Phased Passenger Service Based on 1 Year of Operation

Initial Corridor	Expected Capital Cost in 2010 Dollars[a]	Expected Rolling Stock Costs in 2010 Dollars[b]	Total Estimated Infrastructure and Rolling Costs[c]
Bristol to Richmond	$20 to $23 million	$3.1 million	$26 million
Bristol to DC	$25 to $28 million	$3.1 million	$31 million
Roanoke to DC	$18 to $20 million	$3.1 million	$23 million
Charlottesville to DC	$6 to $7 million	$3.1 million	$10 million

[a]Capital cost for a *pilot* service was available for the first corridor only: Bristol to Richmond (Virginia Department of Rail and Public Transportation, 2005). Capital cost for *full service* was available for all four corridors (Woodside Consulting, 2002). The ratio of pilot service capital costs to full service capital costs for this corridor was used to estimate the costs for pilot service in the other three corridors.
[b]Rolling stock costs were determined by inflating the $2.5 million rolling stock estimate (Virginia Department of Rail and Public Transportation, 2005) into 2010 dollars.
[c]Total estimated costs are the sum of the upper range for expected capital costs plus rolling stock costs.

Develop a Detailed Ridership Test

The ridership forecasts for TDX have varied by a factor of 20, from roughly 25,000 to more than 500,000. If a pilot passenger service is offered, a detailed analysis should be conducted to determine the actual riders of TDX.

This ridership test should use a combination of passenger surveys and train service times to answer several questions. The passenger survey should indicate the travel purpose (e.g., business, tourism, students), the number of riders willing to use the service again, the stations between which passengers are traveling, attitudes toward amenities and reliability, availability of personal vehicles, and the distance between the passengers' station and their final origin or destination. Such survey data should be coupled with actual travel times (as opposed to scheduled travel times), information about comparison automobile travel time, and the frequency of service.

This information should be used to develop a *publicly available* baseline forecast for full TDX service. Although previous forecasts have been developed, the full details of these forecasts are not available. Thus, disparities between forecasts and actual ridership cannot easily be attributed to specific causes, such as a lower-than-expected reliability or higher-than-expected fares. By making a full forecast available to the public, the feasibility of TDX appealing to specific markets, such as tourists, may better be determined. Elsewhere it has been noted that some markets have developed differently than expected (e.g., for the Downeaster, the tourism market has not materialized but the business market has); thus, it is reasonable that in Virginia there may be some surprises as well. The forecasts used in this study are available in Appendices B and C and are documented in the accompanying spreadsheets at http://www.vtrc.net/tdxexpress.

Investigate Options for Selection of an Operator

The 2005 report to the General Assembly noted three possibilities for the entity that should operate the system: Amtrak, Virginia Railway Express (VRE), and Norfolk Southern, as well as advantages of each option (Virginia Department of Rail and Public Transportation, 2005). Two considerations are noted here. One practitioner suggested that the state may have reduced liability risk due to an incident (e.g., if a passenger is injured) if Amtrak operates the system; otherwise, the state may have to purchase additional liability insurance (Eugene Skoropowski, Personal Communication, October 20, 2006). This advantage has been noted for Virginia's TDX (Virginia Department of Rail and Public Transportation, 2005). Another advantage noted by this observer was that Amtrak may have reduced maintenance of way payments (on the order of $1.50 per train mile) to use the system, whereas another operator may have to pay market rates (estimated as approximately $7 per train mile). However, there may also be on-time performance advantages to having the railroad owner—in this case Norfolk Southern—operate the system.

Create an Incentive Structure for the Operator to Provide High-Quality Service

It is possible to devise incentives to encourage the operator to provide high-quality service. For example, in the California Capitol Corridors, three incentives are noted: supplemental maintenance of way payments, supplemental on-time bonus, and incentives for improving on-time bonus (Eugene Skoropowski, Personal Communication, October 20, 2006).

- *Supplemental maintenance of way payments.* Although $1.50 per mile is the statutory maintenance of way payment, an additional $1 per mile is provided by CCJPA to Amtrak—this amounts to about $600,000 to $700,000 per year. These additional funds are used to perform maintenance after hours and thus improve the on-time performance of the system.

- *Supplemental on-time bonus*. In cases where the railroad owner operates the passenger train, the operator could potentially earn a $2.5 million bonus for keeping the trains on schedule.

- *Improved revenue incentive***.** Amtrak serves as the operator under a fixed price contract, where a certain revenue is assumed and a gross budget is constructed. If the revenue is too low, Amtrak assumes that risk. If the revenue exceeds projections, 35% goes to Amtrak and 65% goes to CCJPA; the only stipulation is that the revenue must be fed back into the service. As an example, although the budget calls for 9 round trips to be offered, 16 in fact are—because revenue exceeded projections. (Routes may also be cut without a public hearing that intra-city transit operators must usually conduct.)

Identify Possible Funding Sources

There are two definitive funding sources for these rail improvements in addition to direct authorizations from Virginia's General Assembly and federal earmarks. FRA administers the Railroad Rehabilitation and Improvement Financing (RRIF) Program, which under the recent federal reauthorization (SAFETEA-LU) provides for $35 billion in loans and loan guarantees for various rail improvements, including passenger rail (FRA, 2006). For example, one official with FRA explained that Virginia just received a $72 million loan for VRE (Joe Pomponio, Personal Communication, October 30, 2006). Passenger rail service, such as TDX, is eligible to participate in the RRIF Program provided it does not run on dedicated lines (and since the TDX track is owned by another entity, notably Norfolk Southern, TDX is thus eligible).

At the state level, the Rail Enhancement Fund is authorized by § 33.1-221.1:1.1 of the *Code of Virginia*. Provided this fund serves the public good and its use has the concurrence of the Commonwealth Transportation Board, DRPT may use this fund for

> acquiring, leasing, and/or improving railways or railroad equipment, rolling stock, rights-of-way or facilities, or assisting other appropriate entities to acquire, lease, or improve railways or railroad equipment, rolling stock, rights-of-way or facilities, for freight and/or passenger rail transportation purposes (Virginia General Assembly, 2005).

The Rail Enhancement Fund requires a 30% matching contribution from a non-state source: the source may include the railroad, a regional authority, or a city/county government. This local government role provides interested localities with an opportunity to assist the deployment of TDX by providing additional funding.

There are two additional tentative funding sources that depend on the specific situation. One of these comes from § 33.1-46.1 of the *Code of Virginia*, which allows localities to use urban and secondary allocations for *mass transit* purposes. Under that provision, the state portion of urban and secondary funds may be used for stations and operating costs provided the Commonwealth Transportation Board (CTB) approves. Presumably, it would be up to the CTB to decide whether TDX could qualify as a mass transit effort. However, much of the secondary and urban allocation is federally funded; thus to use those allocations that are federally funded, federal rules apply. It does not appear that FHWA would deem this an eligible activity under federal rules, but because FHWA staff were not definitive in this statement, this area may merit further study in the future. The other source of funding is the Congestion Mitigation and Air Quality (CMAQ) Program, where elements of the passenger rail service that operated in the nonattainment areas might be eligible. However, the amount of CMAQ funds for Virginia is also expected to be limited; thus, the CMAQ Program is not expected to be a significant source.

Limitation of Action Plan Steps

The seven steps are simply one approach Virginia may choose to initiate service. These steps do not replace two challenges that were not resolved in this update. First, because any service would operate on Norfolk Southern lines, detailed discussions need to take place between Virginia and Norfolk Southern. Second, these steps do not eliminate the institutional issues identified previously, notably a dedicated funding source, an appropriate governance structure, measuring system performance, and determining the public and private benefits of proposed capital improvements.

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APPENDIX A
ENABLING LEGISLATION

Item 438.B of HB 5002 in the Chapter 3 Acts of Assembly (the Budget Bill for 2006-2008 biennium) states the following:

> The Department shall report to the Chairmen of the Senate Finance and House Appropriations Committees on the transportation project authorized under the Virginia Transportation Act of 2000 to provide passenger rail service between the Cities of Bristol and Richmond, and Washington, DC. In addition to the project's status, the Department shall include revised information on capital and operating costs, potential revenue of such passenger service, and the project's potential benefits to alleviate congestion on the state's Interstate and highway system of roads. The report shall be submitted by January 2, 2007 (Virginia General Assembly, 2006).

APPENDIX B
DETAILS OF THE METHODOLOGY FOR FORECASTING RIDERSHIP

The following steps are the approach used to forecast the ridership as a function of travel time. These steps generated Tables 6, 7, and 8 in the report.

1. *Determine the number of potential non-business trips.*

   In this study, non-business trips are those made by college students, tourists, and non-vehicle households.

   - For each station, identify the city/town plus surrounding county/counties in which it sits. For example, the Charlottesville station should correspond to the City of Charlottesville and Albemarle County, and the Roanoke station should correspond to the City of Roanoke and Roanoke County. The sum of all such station populations is 3.95 million. These data are in the "Total Population" tab of the *TDX Ridership Data* spreadsheet at http://www.vtrc.net/tdxexpress.

   - Divide the sum by the total statewide population. For example, because there are 7.6 million people in the Commonwealth, this means that TDX would have access to 45% of the state's population. This number is the *Corridor Population Percentage.*

   a. *College students*

      Determine the number of college students with access to TDX based on colleges listed in each jurisdiction or bordering jurisdiction where a station stop is situated. For example, the relevant college in Charlottesville/Albemarle would be the University of Virginia, and the relevant colleges in Roanoke/Roanoke County would be Roanoke College and Hollins University.

      - Determine the number of in-state students at each school using enrollment records.

      - Multiply that number by 45% (*Corridor Population Percentage)* to obtain the number of students with residences along the TDX corridor.

      - Multiply the number by 8, assuming four round trips between home and college for each student per year.

      This gives the potential number of college student one-way trips between school and home along the TDX corridor (assume four trips per year). See the "Student Population" tab of the *TDX Ridership Data* spreadsheet.

      Examples:

      For the Charlottesville station: The University of Virginia has 9,369 in-state students, an estimated 45%, or 4,335, of whom have homes served by a TDX station. This group can be expected to make 34,676 total trips between home and school during the school year.

For the Roanoke station: Hollins University and Roanoke College have a combined 1,533 in-state students, an estimated 45%, or 689, of whom have homes served by a TDX station. This group can be expected to make 5,514 total trips between home and school during the school year.

b. *Tourists*

Determine the total number of tourists visiting each jurisdiction served by a station.

- Determine the total number of tourists visiting Virginia each year. The Virginia Tourism Corporation (VTC) estimated that number as 54.8 million in 2005. *Source:* http://www.vatc.org/research/DKSAVisitationEstimates2005.pdf.

- Determine the estimated tourism spending in each jurisdiction served by a TDX stop as a percentage of the total tourism spending in the state. For example, the City of Charlottesville and Albemarle County accounted for 2.2% of the total tourism spending in 2005, and the City of Roanoke and Roanoke County accounted for 2.5%. *Source:* http://virginiascan.yesvirginia.org/localspending/.

- Multiply this tourism spending percentage by the total number of tourists visiting the state to determine total tourists per jurisdiction. *Note:* This formula produces results that best match the rough estimates received from interviews with local tourist bureaus. No uniform local tourist estimate formula exists in Virginia.

- Multiply the total tourists per jurisdiction by 21%, the VTC estimate of tourists visiting from inside Virginia. *Source:* http://www.vatc.org/research/WheredoVAsVisitorscomefrom.pdf.

- Multiply the result by the Corridor Population Percentage, 45%, to determine the number of potential tourists that will visit one TDX-served jurisdiction from another. *Note:* This does not account for any out-of-state tourists who use TDX to visit Virginia.

- Multiply the number by 2, assuming 1 round trip per year.

This gives the potential number of tourist one-way trips to a TDX destination. See the "Tourist Population" tab of *TDX Ridership Data* spreadsheet.

Examples:

For the Charlottesville station: 2.2% of the 54.8 million state visitors yields approximately 1.2 million visitors per year: 21%, or 253,176, originate inside the state; 45% of that number, or 113,855, comes from a TDX jurisdiction. Assuming two trips a year yields a potential 227,710 TDX tourist trips per year.

For the Roanoke station: 2.5% of the 54.8 million state visitors yields approximately 1.37 million visitors per year: 21%, or 287,700, comes from inside the state; 45% of that number, or 129,381, comes from a TDX jurisdiction. Assuming one round trip a year yields a potential 258,761 TDX tourist trips per year.

c. *Non-vehicle households*

Determine the total number of personal trips made by members of non-vehicle households. These data are accessible at http://ctpp.transportation.org/home/va.htm, which is the Census Transportation Planning Package. For example, according to the 2000 Census, Charlottesville/Albemarle has 3,787 non-vehicle households. Roanoke/Roanoke County has 6,768 non-vehicle households.

- Multiply the total non-vehicle household number by the Corridor Population Percentage, 45%, to determine non-vehicle household members who will visit one TDX-served jurisdiction from another. *Note:* This does not account for any out-of-state members of non-vehicle households who use TDX to visit Virginia.

- Multiply the number by 2, assuming 1 round trip per year.

This gives the potential number of personal visit trips to a TDX destination. See the "Non-Vehicle Population" tab of the *TDX Ridership Data* spreadsheet.

Examples:

For the Charlottesville station: Taking 45% of the 3,787 households yields 1,704 non-vehicle households with a potential destination along the TDX corridor. Assuming one round trip a year yields a potential 3,406 TDX non-vehicle household personal trips per year.

For the Roanoke station: Taking 45% of the 6,768 households yields 3,046 non-vehicle households with a potential destination along the TDX corridor. Assuming one round trip a year yields a potential 6,087 TDX non-vehicle household personal trips per year.

d. *Total non-business trips*

Sum the results from steps *a* through *c* for each station to obtain the total potential non-business trips from each station. For example, the result for the Charlottesville station is 34,676 potential college trips annually; 227,710 potential tourist trips annually; and 3,406 potential trips from non-vehicle households annually; for a total of 265,792 potential TDX non-business trips. See the "Non-Bus Trip Totals" tab of the *TDX Ridership Data* spreadsheet. Again, these are total potential trips; the number of rail trips will be far fewer.

2. *Select a total of six stations for further analysis, with at least one station from each region*.

   As shown in the *TDX Ridership Data* spreadsheet, the six stations with the highest ridership and that spanned the entire TDX network were Radford, Roanoke, Lynchburg, Charlottesville, Alexandria, and Richmond.

3. *Estimate the total potential non-business ridership between each pair of stations*.

   a. *Population and employment*

      At these same stations, sum the combination of population and employment. The Charlottesville/Albemarle population is roughly 131,154, and its employment is roughly 82,178, for a total of 213,332. Call this A1, A2, A3, A4, A5, and A6 for each area. See the "Non-Bus Gravity Model" tab of the *TDX Ridership Data* spreadsheet.

   b. *Distance between stations*

      Between each station, write down the inverse of distance. For example, since Radford (station 1) is 42 miles from Roanoke (station 2), write down that D_{12} = 1/42 = 0.02. See the "Non-Bus Gravity Model" tab of the *TDX Ridership Data* spreadsheet.

   c. *Potential demand*

      Estimate the potential demand between each pair of stations based on the following formula:

$$\text{Potential travel}_{12} = \frac{S_1 A_2 D_{12}}{A_1 D_{11} + A_2 D_{12} + A_3 D_{13} + A_4 D_{14} + A_5 D_{15} + A_6 D_{16}}$$

      The equation simply follows the gravity model and allows us to estimate the demand for travel between stations 1 and 2 based on the total trips originating or terminating at station 1 and the relative attractiveness (and distance) of stations 2, 3, 4, 5, and 6 from station 1. Note that D_{11} is zero.

      Example: Suppose Charlottesville is station 1 and Roanoke is station 2. Roanoke has a population of 180,803 and an employment of 105,527; thus, A_1 = the sum of these two, which is 286,330. Step 1d suggested that Charlottesville could generate 265,792 trips, which is thus S_1. The inverse of the distance between Charlottesville and Roanoke, D12, is 1/112.85 = 0.00886. Thus, the product of $S_1A_1D_{12}$ is 674,283,419, which goes into the numerator of the equation. The denominator is computed in a similar manner, as shown in the "Non-Bus Gravity Model" tab of the *TDX Ridership Data* spreadsheet.

   d. *Balancing demand*

      The equation will show a different number of trips between two stations because the sum of employment and population (A) is not equal to the number of trips generated (S). The number of trips is the critical amount; thus, keep S constant but ensure that the number of

trips between two stations is equal. For example, the equation yields 7,134 trips from Radford to Charlottesville and 7,713 from Charlottesville to Radford. Thus, these two numbers are summed and divided by 2 to show 7,423 trips from each station to the other, as shown in Table 6 in the body of the report.

4. *Repeat the first three steps to determine business ridership*.

   The county to county worker flow files show the number of business trips between counties in Virginia at http://www.census.gov/population/cen2000/commuting/2KRESCO_VA.xls (U.S. Census Bureau, 2003). The data show the number of workers who reported the destination county as their principal place of work during the reference week. This is the location at which they worked most of the time; it could be as little as 1 day (or even a part of a day) or the entire week. *Source:* Email conversation with Phillip Salopek at the U.S. Census Bureau, 10/31/06.

   To determine workers traveling to work from a particular jurisdiction along the TDX corridor, combine the values in the "Count" column for a particular jurisdiction in which the "Workplace State-County Name" is another jurisdiction in Virginia. For this exercise, exclude the city and county from which the particular worker starts, as there is no chance the worker would be able to take TDX to work in his or her own jurisdiction.

   For example, there are 66 workers traveling from Lynchburg to Charlottesville, 208 workers traveling from Amherst County to Charlottesville, and 42 workers traveling from Campbell County to Charlottesville, as shown in lines 6195, 237, and 840 of the spreadsheet entitled "2KRESCO_VA." Assuming these 66 + 208 + 42 = 316 workers make 300 one-way trips annually (based on two-way travel 3 days per week, 50 weeks per year), from Lynchburg to Charlottesville there might be (316)(300) = 94,800 trips. A comparable calculation suggests 32,700 trips from Charlottesville to Lynchburg. Balancing these two numbers suggests a total of (94,800 + 32,700)/2 = 63,750 trips between the two stations, as shown in Table 7 in the body of the report.

5. *Determine the sensitivity of non-business demand for rail as a function of travel time*.

   a. *Auto and rail service times*

      Determine auto service times between each pair of stations. (For example, Mapquest suggests that the travel time between Lynchburg and Washington, DC, is 4 hours.) These are placed in Table B1. Select rail service times from the train schedule (Woodside Consulting, 2002). These are also shown in Table B1.

Table B1. Rail and Auto Travel Time Between Stations

Travel Times[a]	Radford (1)		Roanoke (2)		Lynchburg (3)		Charlottesville (4)		Alexandria (5)		Richmond (6)	
	Auto	**Train**	**Auto**	**Train**	**Auto**	**Train**	**Auto**	**Train**	**Auto**	**Train**	**Auto**	**Train**
Radford (1)	--	--	53	88	115	168	154	240	276	299	217	88
Roanoke (2)	52	88	--	--	69	80	119	152	242	270	183	300
Lynchburg (3)	115	178	69	76	--	--	79	67	208	186	142	175
Charlottesville (4)	154	243	119	155	79	73	--	--	137	119	72	459
Alexandria (5)	276	364	242	276	208	194	137	121	--	--	106	880
Richmond (6)	217	379	183	291	142	175	72	332	106	571	--	--

[a]Source: Woodside Consulting, 2002: see Timetables, Attachment C. In situations where there are multiple routes from Richmond to/from points north of Lynchburg, we chose the fastest time with the shortest layover.

b. *Sensitivity of demand to travel time*

Estimate the sensitivity of travel time to ridership based on the following four equations:

$$\text{Percent Trips by Rail} = 0.0723\,(\text{percent time saved by rail}) + 0.0291$$
$$\text{Percent Trips by Rail} = 0.0862\,(\text{percent time saved by rail}) + 0.0126$$
$$\text{Percent Trips by Rail} = 0.0615\,(\text{percent time saved by rail}) + 0.0060$$
$$\text{Percent Trips by Rail} = 0.0083\exp\,(4.3523\ \text{percent time saved by rail})$$

For example, the travel time by auto from Lynchburg to Richmond is given as 142 minutes. Appendix C (Woodside Consulting, 2002) suggests a train time of 175 minutes. This suggests that rail would require an extra 23% travel time. Thus, in the three equations, the percent trips by rail is estimated as

$$\text{Percent Trips by Rail} = 0.0723\,(-0.23) + 0.0291 = 1.23\%$$
$$\text{Percent Trips by Rail} = 0.0862\,(-0.23) + 0.0126 = -0.7\%\ \text{(hence zero trips by rail)}$$
$$\text{Percent Trips by Rail} = 0.0615\,(-0.23) + 0.0060 = -0.8\%\ \text{(hence zero trips by rail)}$$
$$\text{Percent Trips by Rail} = 0.0083\exp\,(4.3523\,(-0.23)) = 0.003\%$$

Thus, the percentage of trips by rail is reported as being between 0% and 1.23%. Given that Table 6 in the body of the report suggested 55,233 non-business trips from Lynchburg and Richmond and that Table 7 suggested 30,300 business trips from Lynchburg to Richmond, there are a total of 85,433 trips by some mode from Lynchburg to Richmond. The four equations suggest that the percentage taken by rail might range from 1.23% of 85,533 (i.e., 1,052) to as low as 0. This range is shown in Table 8 in the body of the report.

The rationale behind these four equations is given in Appendix C.

APPENDIX C
RATIONALE FOR THE DEMAND ESTIMATION EQUATIONS

The demand functions used in previous studies were not directly available. However, the 2000 report by Amtrak (National Railroad Passenger Corporation, 2000) appeared to critique only the assumed service levels and not the demand functions themselves; e.g., the report notes that "while the Phase 2 Report [that done by Frederic R. Harris in 1998] simulations are accurately depicting the input assumptions used in that report, the input assumptions themselves need credible review" (National Railroad Passenger Corporation, 2000). Accordingly, as shown in Table C1, the ridership levels as a function of travel time were determined based on previous studies. These ridership levels are shown in Table C1, and their extraction is shown in the sheet *TravelDemandFunction*s in the spreadsheets at http://www.vtrc.net/tdxexpress.

Table C1. Estimated Ridership Levels from the 1996, 1998, and 2000 Studies as a Function of Train Travel Time

Train Service	All Phases		Phase 1[a]		Phase 2[a]		Amtrak[b]	
	Total Auto and Rail Trips	Auto Travel Time[c]	Train Travel Time	Train Ridership[d]	Train Travel Time	Train Ridership[d]	Train Travel Time	Train Ridership[e]
Bristol to Lynchburg	1,723,690	206	234	34,416	253	20,988	287	2,191
Lynchburg to DC	13,610,321	204	156	271,748	196	165,724	209	17,303
Lynchburg to Richmond	1,422,623	142	130	28,405	144	17,322	161	1,809

[a]These train travel time and train ridership data are based on Table 4-3 of the chapter entitled Section 4, Ridership Forecasts produced by Frederic R. Harris, Inc., in a 1997 draft for DRPT (see the column entitled "Phase 1 Forecast, $0.17/mile fare" and "Phase 2 Forecast, $0.17/mile fare," respectively).
[b]These are based on the Amtrak alternate schedule presented in National Railroad Passenger Corporation, 2000.
[c]These are based on choosing the shortest travel time from Mapquest, accessed at http://www.mapquest.com/ on October 27, 2006. All travel times are in minutes.
[d]Although total ridership levels were given for each forecast, individual ridership levels were not. However, individual station boardings and alightings were given elsewhere in the 1997 draft for DRPT for a slightly different total ridership than that used in the rightmost column. These individual boardings and alightings were used to make a rough estimate of the contribution of each station to the total ridership. Then, the proportion of total ridership attributable to each TDX segment could be determined. Finally, these proportions were applied to the total ridership levels to determine the values shown. The final proportions used were 5% (Bristol/Lynchburg), 42% (Lynchburg/DC), 4% (Lynchburg/Richmond), and 48% (Richmond/DC). Because Richmond/DC was extraordinarily long, it is not used in the table.
[e]The total predicted ridership of 26,252 was distributed to the three service segments, presuming 4% (Lynchburg/ Richmond), 5% (Bristol/Lynchburg), and the sum of the remaining two segments to Lynchburg/DC As a rough check, when the estimated proportion for Richmond to Washington was added to 26,252 the sum was similar to the value shown in the Modified Plan from (National Railroad Passenger Corporation, 2000)

The data in Table C1 were used to calibrate the four demand functions shown in Appendix B. These demand functions give the proportion of trips by rail as a function of travel time. Note that in Table C1, the proportion of trips by rail always appears quite low (on the order of 2% even if rail were to save 20% time compared to the auto). Should an operational test be undertaken, assumptions such as these could be studied in detail and modified accordingly.

The reason for the four demand functions is that with the limited data set there is a variety of ways to assess the data. For example, an optimistic forecast can be obtained by using the first demand function shown as Eq. C1, which is based on the most optimistic values only from each study shown in Table C1 (e.g., the value that gave the largest ridership for a given service level). A more pessimistic forecast would be obtained from using either Equation C2 or C3. If all nine data points are used in the calibration, Eq. C4 results, which tends to assume there will be some captive riders regardless of rail service time.

$$\text{Percent Trips by Rail} = 0.0723\,(\text{percent time saved by rail}) + 0.0291 \qquad \text{(Eq. C1)}$$
$$\text{Percent Trips by Rail} = 0.0862\,(\text{percent time saved by rail}) + 0.0126 \qquad \text{(Eq. C2)}$$
$$\text{Percent Trips by Rail} = 0.0615\,(\text{percent time saved by rail}) + 0.0060 \qquad \text{(Eq. C3)}$$
$$\text{Percent Trips by Rail} = 0.0083\exp\,(4.3523\,\text{percent time saved by rail}) \qquad \text{(Eq. C4)}$$

Given the literature's admonition that demand forecasts are highly variable (Evans, 2004; Vaca, 1993) it is most appropriate to present the forecasts as a range of values rather than as a single number. Thus, the range of forecasts is used.

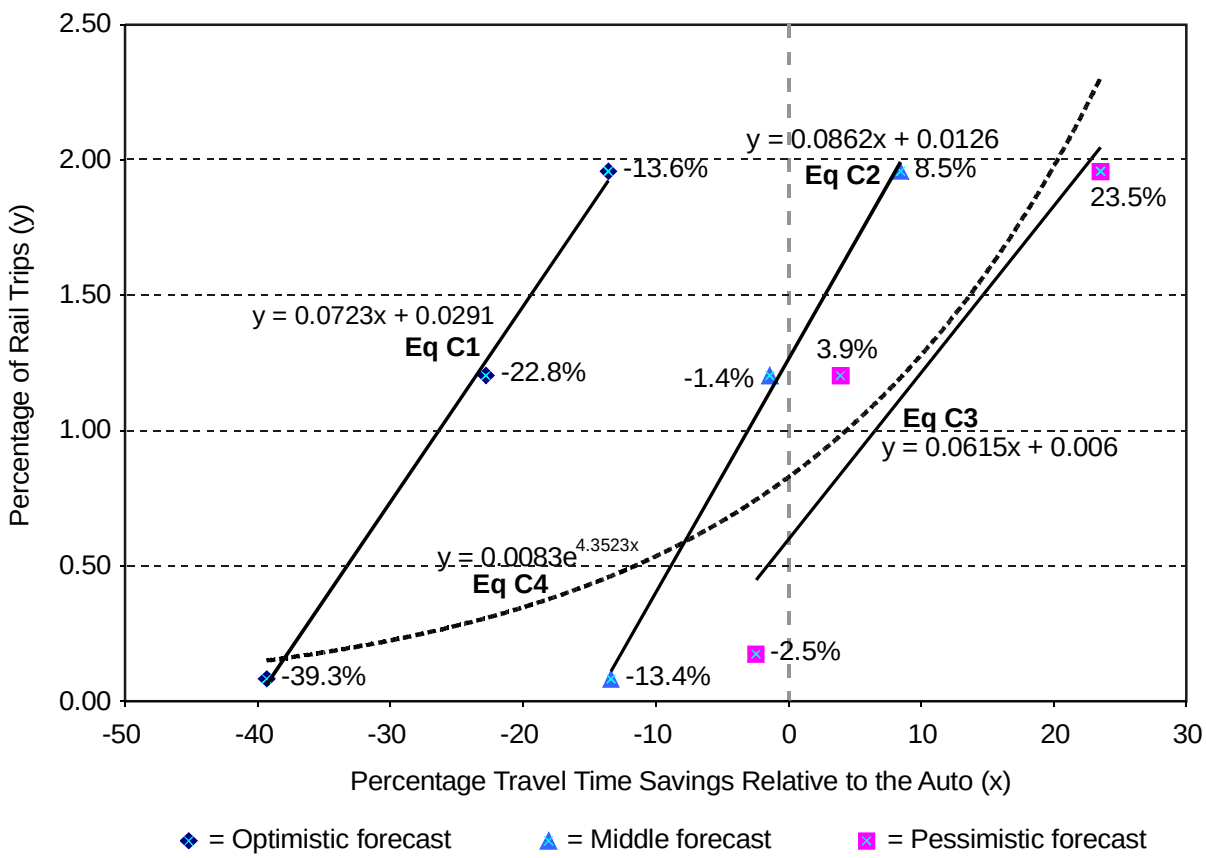

Figure C1. Data Used to Estimate Travel Demand as a Function of Rail Service Time

DRPT

Virginia Department of Rail and Public Transportation

The Smartest Distance Between Two Points